Seating for PHYS 1020 Term Test, 2007
Tuesday, October 23, 7-9 pm

Student numbers		Room
From	To	
6504394	6842355	200 Fletcher-Argue
6842547	6852067	200 Armes
6852080	6852939	206 Tier
6852942	6855233	306 Tier
6855256	7607350	223 Wallace

GENERAL PHYSICS I: PHYS 10

Schedule - Fall 2007
(lecture schedule is approximate)

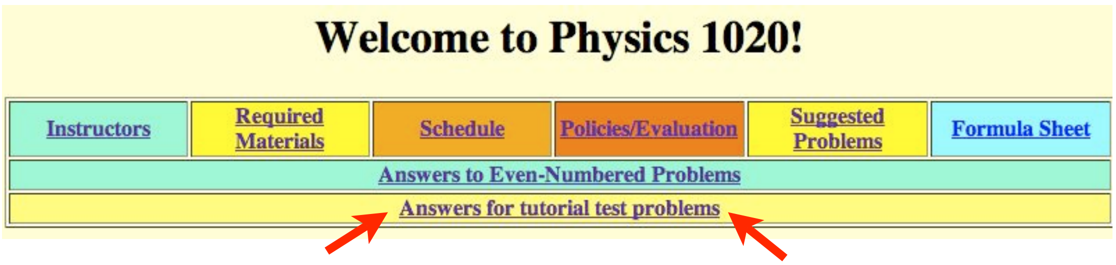
	W	3	12	Chapter 5	Uniform circular motion	(chapters 1, 2, 3)
	F	5	13			
6	M	8	Thanksgiving Day			Experiment 2: Measurement of g by free fall
	W	10	14	Chapter 5	Uniform circular motion	
	F	12	15	Chapter 6	Work and energy	
7	M	15	16			Tutorial and Test 2 (chapters 4, 5)
	W	17	17			
	F	19	18	Chapter 7	Impulse and momentum	
8	M	22	19			No lab or tutorial
	Tue	23	MID-TERM TEST, Ch 1-5, Tuesday, October 23, 7-9 pm			
	W	24	20	Chapter 7	Impulse and momentum	
	F	26	21	Chapter 8,		

Week of October 15: Tutorial and test 2: ch. 4, 5

Tuesday, October 23, 7-9 pm, midterm: ch. 1-5
(20 multiple-choice questions)

Answers for Tutorial Tests

A link to answers for the tests can be found on the PHYS 1020 home page:



...but only for test 1 so far!

Things Centripetal

or, flying off in all directions

Acceleration toward centre of a circular path of radius r:

$$a_c = v^2/r$$

Force needed to maintain the centripetal acceleration = centripetal force:

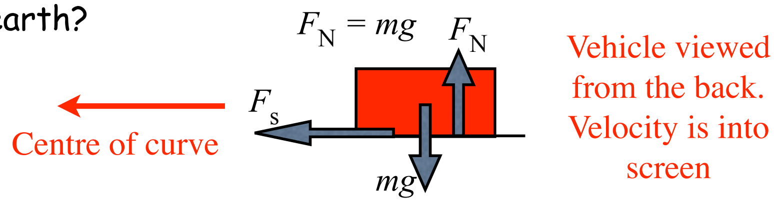
$$F_c = ma_c = mv^2/r$$

Force provided by tension in a string, friction, horizontal component of airplane's lift, gravity...

NB centrifugal force is the force you feel toward the outside of a curve when going around a corner. It's not really a force, but a consequence of Newton's first law that says that things travel at constant velocity (so, in a straight line) unless a force is applied.

Clickers!

5.C6: Other things being equal, would it be easier to drive at high speed (no skidding) around an unbanked horizontal curve on the moon than to drive around the same curve on the earth?

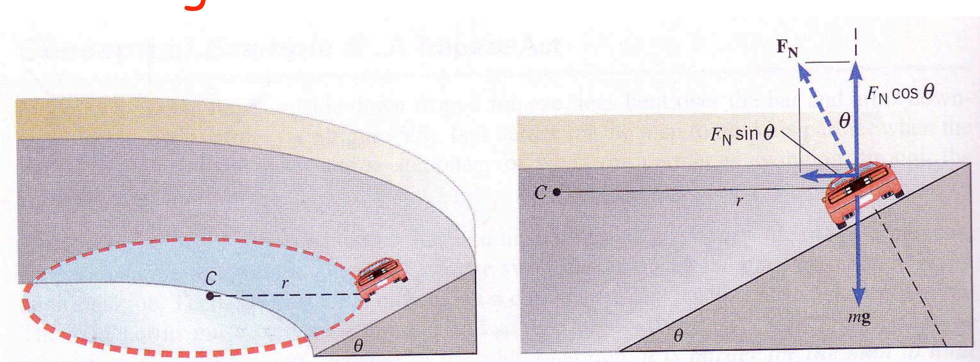


A) Yes, easier on the moon, B) No, more difficult on moon

C) Just the same D) Who knows?

The centripetal acceleration is provided by friction.
The friction force is proportional to the normal force.
The normal force is equal to the weight of the car.
On the moon, the acceleration due to gravity, g_{moon}, is ≈ g/6 ...

Driving around in circles – banked road



No friction!!

As for plane but with lift force replaced by normal force:

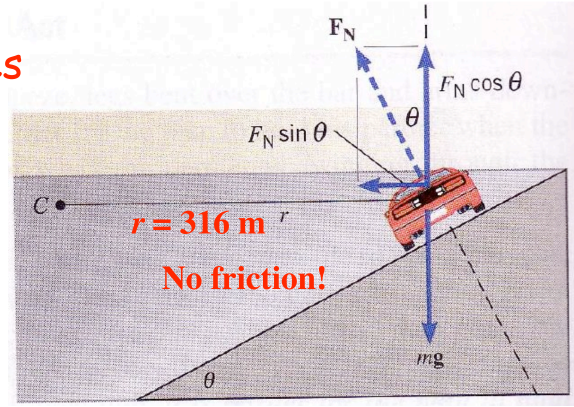
$$F_N \sin\theta = \frac{mv^2}{r}$$

$$F_N \cos\theta = mg$$

$$\rightarrow \tan\theta = \frac{mv^2}{r} \times \frac{1}{mg} = \frac{v^2}{rg}$$

→ best angle of banking (same as for plane)

Driving around in circles – banked curve



If you drive slowly, you slide **down** the slope.

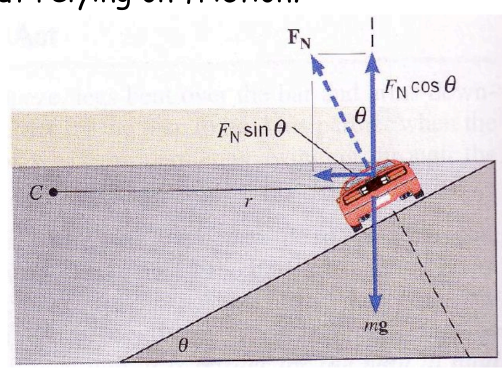
If you drive fast, you skid **up** the slope.

If θ = 31^0 and r = 316 m, and there is no friction, what is the best speed to drive around the banked curve?

$$\tan\theta = \frac{v^2}{rg}, \text{ so } v = \sqrt{rg\tan\theta}$$

$$v = \sqrt{316 \times 9.8 \tan 31^\circ} = 43.1 \text{ m/s} \ = 155 \text{ km/h}$$

5.20/-: Two banked curves have the same radius. Curve A is banked at 13^0, curve B at 19^0. A car can travel around curve A without relying on friction at a speed of 18 m/s. At what speed can this car travel around curve B without relying on friction?



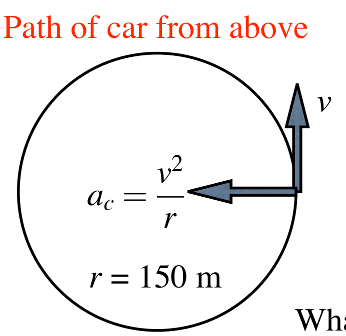
From previous page: $v = \sqrt{rg\tan\theta}$

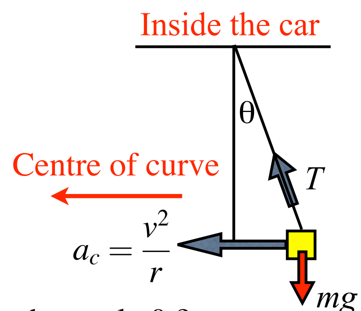
That is, $v \propto \sqrt{\tan\theta}$

$$\text{So } \frac{v_A}{v_B} = \sqrt{\frac{\tan\theta_A}{\tan\theta_B}} = \sqrt{\frac{\tan 13^\circ}{\tan 19^\circ}} = 0.819$$

Therefore, $v_B = v_A/0.819 = 22$ m/s

5.18: A car travels at 28 m/s around a curve of radius 150 m. A mass is suspended from a string from inside the roof.





What is the angle θ ?

Force toward centre of circular path due to tension in the string:

$$\frac{mv^2}{r} = T\sin\theta \qquad \rightarrow \tan\theta = \frac{v^2}{rg}$$

Forces in the vertical direction: $mg = T\cos\theta$

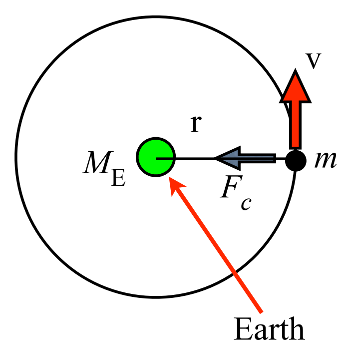
$$\tan\theta = \frac{28^2}{150g} = 0.5333$$

$$\theta = 28.1^\circ$$

Orbiting the Earth

"The secret to flying is to throw yourself at the earth and miss."
Hitch Hiker's Guide to the Galaxy

The centripetal force on the satellite is provided by the gravitational force from the earth.



$$F_c = \frac{mv^2}{r} = \frac{GM_E m}{r^2}$$

$$\text{So } v = \sqrt{\frac{GM_E}{r}}$$

the smaller the radius, the greater the speed

Synchronous orbit: period = 24 hours

- satellite stays above same part of the earth (above the equator)
- used by communications satellites
- what is the radius of the orbit?

Synchronous Orbit – what is its radius?

The period of an orbit is: $T = \dfrac{\text{circumference of orbit}}{\text{speed of satellite}} = \dfrac{2\pi r}{v}$

What is v?

From previous page, $v = \sqrt{\dfrac{GM_E}{r}}$

So $T = 2\pi r \times \sqrt{\dfrac{r}{GM_E}} = 2\pi \times r^{3/2}\sqrt{\dfrac{1}{GM_E}}$

$$r^3 = GM_E \left(\frac{T}{2\pi}\right)^2$$

(Kepler's 3rd law of planetary motion: $T^2 \propto r^3$)

With $T = 24 \times 3600$ s, $r = 4.23 \times 10^7$ m $= 42{,}300$ km from centre of earth

The speed of the satellite is: $v = \dfrac{2\pi r}{T} = 3070$ m/s $= 11{,}000$ km/h

5.32/34: The earth orbits the sun once per year at a distance of 1.5×10^{11} m.

Venus orbits the sun at a distance of 1.08×10^{11} m.

What is the length of the year on Venus?

Kepler: $T^2 \propto R^3$,

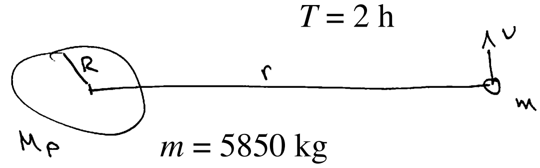
so, $\left(\dfrac{T_V}{T_E}\right)^2 = \left(\dfrac{R_V}{R_E}\right)^3 = \left(\dfrac{1.08}{1.5}\right)^3 = 0.373$

$$T_V = 0.611 T_E$$

The length of the year on Venus is 0.611 Earth years.

5.33: A satellite has a mass of 5850 kg and is in a circular orbit 4.1×10^5 m above the surface of a planet. The period of the orbit is 2 hours. The radius of the planet is 4.15×10^6 m. What is the weight of the satellite when it is at rest on the planet's surface?

$T = 2$ h



What is g at $r = R$?
Need the mass M_p of the planet.

$m = 5850$ kg
$R = 4.15 \times 10^6$ m
$r = 4.1 \times 10^5 + R = 4.56 \times 10^6$ m

The speed of the satellite in orbit is $v = 2\pi r/T$

$$\text{Centripetal force, } F_c = \boxed{\frac{mv^2}{r} = \frac{GmM_p}{r^2}} \rightarrow GM_p = v^2 r = \left[\frac{2\pi}{T}\right]^2 r^3$$

$$\text{Then, weight on planet's surface, } mg_p = \frac{GmM_p}{R^2} = \frac{m}{R^2}\left[\frac{2\pi}{T}\right]^2 r^3$$

$$\text{Weight} = \frac{5850}{(4.15 \times 10^6)^2}\left[\frac{2\pi}{2 \times 3600}\right]^2 \times (4.56 \times 10^6)^3 = 2.45 \times 10^4 \text{ N}$$

($g_p = 4.2$ m/s^2)

Free Fall, Weightlessness

An orbiting satellite is in free fall – there's nothing to hold it up.

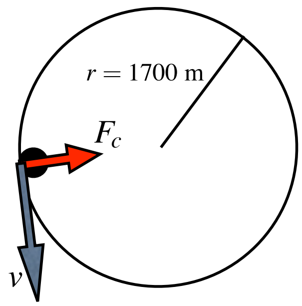
Only its forward speed lets it "miss the earth" (Hitch Hiker's Guide!) and keep orbiting.

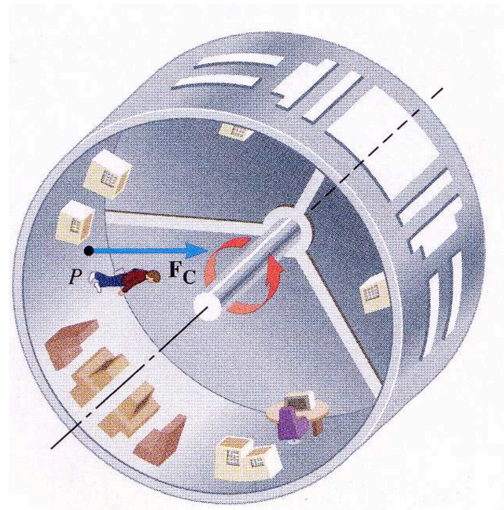
Everything in the satellite is accelerated toward the centre of the earth at the same rate.

An object exerts no force on the bathroom scales as the scales are also being accelerated toward the centre of the earth.

Artificial Gravity

A space station is rotating about its axis to provide an artificial gravity.



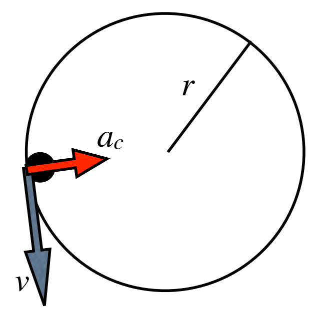


$$F_c = \frac{mv^2}{r}$$ – make this equal to the person's weight on earth, mg

$$\frac{mv^2}{r} = mg \rightarrow v = \sqrt{rg} = \sqrt{1700 \times 9.8} = 129 \text{ m/s}$$ ($2\pi r/v = 83$ seconds per revolution)

Artificial Gravity

5.28/-: Problems of motion sickness start to appear in a rotating environment when the rotation rate is greater than 2 revolutions/ minute.



Find the minimum radius of the station to allow an artificial gravity of one gee (a_c = 9.8 m/s^2) while avoiding motion sickness.

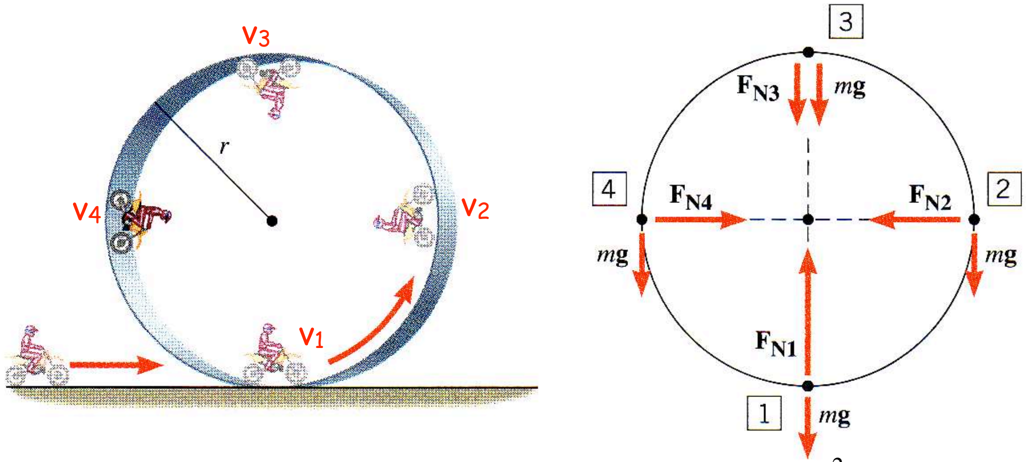
From previous slide, get $a_c = g$ artificial gravity when: $v = \sqrt{rg}$

Period of rotation, $T = \frac{2\pi r}{v} = \frac{2\pi r}{\sqrt{rg}} = 2\pi\sqrt{\frac{r}{g}}$

So, $r = \left[\frac{T}{2\pi}\right]^2 g = 223 \text{ m}$ (for $T = 30$ s)

The minimum radius of the space station is 223 m

Vertical Circular Motion

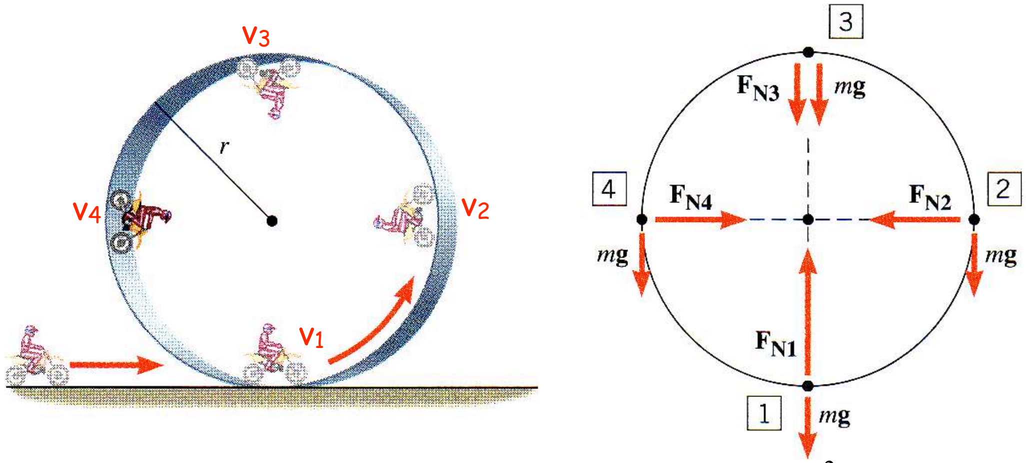


At (1): Net force toward centre of circle $= F_{N1} - mg = \dfrac{mv_1^2}{r}$

$$F_{N1} = mg + \frac{mv_1^2}{r} \qquad \text{(greater than the weight)}$$

At (2): Force toward centre of circle $= F_{N2} = \dfrac{mv_2^2}{r}$

Vertical Circular Motion



At (3): Net force toward centre of circle $= F_{N3} + mg = \dfrac{mv_3^2}{r}$

$$F_{N3} = \frac{mv_3^2}{r} - mg \qquad \text{Falls off if } F_{N3} = 0, \text{ i.e. } v_3 \leq \sqrt{rg}$$

At (4): as for (2)

Chapter 5: Uniform Circular Motion

- Period of circular motion: $T = 2\pi r/v$
- Centripetal acceleration: $a_c = v^2/r$
- Centripetal force: $F_c = ma_c = mv^2/r$
- For motion in a horizontal circle,
  - equilibrium in the vertical direction, vertical forces cancel
  - use Newton's second law to relate net horizontal force to the centripetal acceleration